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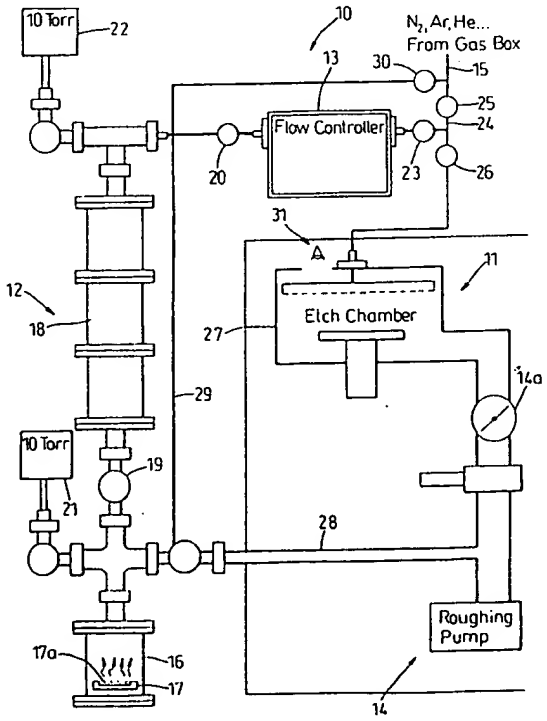
(54) Method and apparatus for etching a workpiece

(57) An XeF_2 source 12 comprises a XeF_2 source chamber 16, which includes a tray or ampoule 17 for XeF_2 crystals 17a, a reservoir 18 via valve 19, a flow controller 13 fed by the reservoir 18 and a valve 20 between the reservoir 18 and the controller 13. Pressure sources 21 and 22 are provided respectively to maintain the reservoir 18 and the source chamber 16 at the sublimination pressure of XeF_2. The arrangement allows for a steady supply of XeF_2 to an etching chamber.



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Description

This invention relates to methods and apparatus for etching a workpiece using Xenon Difluoride (XeF_2). Xenon Difluoride is a dry isotropic gas phase etchant, which provides a gentle etch for silicon at low temperature. Xenon Difluoride is usually supplied in the form of colourless crystals which sublime without decomposition. The sublimation pressure for XeF_2 is approximately 4 Torr.

Present attempts to use XeF_2 for etching have been essentially experimental and have taken place using a pulsed supply of XeF_2 which requires the etch to be stopped and started with the etch chamber being pumped down between each etch step. Such an arrangement is impracticable for production processes. Direct flow has been attempted unsuccessfully.

From one aspect the invention consists in a method of etching a workpiece using XeF_2, comprising allowing XeF_2 in its solid phase to sublimate into its gaseous state into a reservoir of sufficient volume to provide gas at a pre-determined flow rate for a pre-determined etch period, supplying the gas at the desired flow rate to an etching chamber containing the workpiece and etching the workpiece.

The XeF_2 gas may be mixed with an inert carrier gas prior to its introduction into the etch chamber. It is particularly preferred that the XeF_2 source continues to sublimate during the outward flow of XeF_2 from the reservoir. Additionally or alternatively the reservoir may be recharged between the etching of separate workpieces.

From a further aspect the invention consists in apparatus for etching a workpiece comprising, an etched chamber, a XeF_2 source, a reservoir, valve means for connecting the source to the reservoir to allow sublimination of the source into XeF_2 gas, a flow controller for feeding the etch chamber and valve means for connecting the reservoir to the flow controller.

Preferably the apparatus includes pressure control means for maintaining the reservoir at approximately the sublimination pressure of XeF_2 when there is no outward flow from the reservoir. Means may be provided for mixing the XeF_2 gas with an inert carrier gas prior to its introduction into the process chamber. It is particularly preferred that the flow controller is a pressure-based flow controller.

A chamber will normally be provided for the solid XeF_2 and conveniently the reservoir may have a volume which is approximately three times the volume of the XeF_2 chamber.

Although the invention has been described above, it is to be understood that it includes any inventive combination of the features set out above or in one following description.

The invention may be performed in various ways and a specific embodiment will not be described, by way of example, reference to the accompanying drawing, which is a schematic view of etching apparatus.

Etching apparatus is generally indicated at 10 and comprises at etch chamber 11, a XeF_2 supply generally indicated at 12, a flow controller 13, a roughing pump assembly, generally indicated at 14, and a carrier gas supply 15.

The XeF_2 supply comprises a XeF_2 source chamber 16, which includes a tray or ampoule 17 for the XeF_2 crystals 17a. The source chamber 16 is connected to a reservoir 18 via a valve 19, which in turn is connected to the flow controller 13 by a valve 20. Pressure sources 21 and 22 are provided to respectively maintain the reservoir 18 and source chamber 16 at approximately 4 Torr which is the sublimination pressure of XeF_2. Downstream of the controller 13 is a valve 23 which connects the flow controller to a supply line 24 between valves 25 and 26. Valve 25 controls the flow of the carrier gas from supply 15 into the supply line 24, whilst valve 26 controls the supply of gases in the supply line 24 to an etch chamber 27 of the etching apparatus 11. As is conventional the roughing pump installation 14 is connected downstream of the etch chamber 27, but it is also connected to the source chamber 16 via bypass 28. A line 29 and valve 30 allows carrier gas to be supplied to this region for purging purposes.

In this the XeF_2 crystals are placed in the ampoule or tray 17 with the valve 19 closes and valve 30 open. Carrier gas is used to purge the chamber and the roughing pump assembly 14 pumps the source down to the sublimination pressure. The roughing pump assembly and carrier gas are then isolated and valve 19 is opened allowing XeF_2 gas to expand or diffuse into the reservoir 18.

A wafer is then loaded into the etch chamber 27 using conventional apparatus and valves 20, 23, 25 and 26 open sequentially to allow XeF_2 and the carrier gas into the etch chamber where etching occurs spontaneously. The pressure within the chamber is controlled by the roughing pump assembly 14 and its automatic pressure control valve 14a. On certain occasions carrier gas may not be required in which case valve 25 remains closed.

Valve 19 may be open or closed, depending on the process and production levels which are required. A optical detector generally indicated at 31 determines when the etch has been completed or alternatively a time basis may be used. Upon completion of the etch valves 20, 23, 25 and 26 are shut and the wafer is removed. By the time a new wafer is introduced into the chamber for etching the reservoir 18 is re-charged and thus not only can each wafer be fully etched in one process, continuous etching of wafers is achieved. Continuous delivery of XeF_2 also enhances uniformity and the use of a pressure based flow control mechanism 13 is considerably beneficial over say mass flow measurement. It will be noted that the process chamber pressure control is independent of the flow control mechanism for XeF_2.

Claims

1. A method of etching a workpiece using XeF_2, comprising allowing solid XeF_2 to subliminate into its gaseous state into a reservoir of sufficient volume to provide gas at a pre-determined flow rate for a pre-determined etch period, supplying the gas at the desired flow rate to an etching chamber containing the workpiece and etching the workpiece.

2. A method as claimed in Claim 1 wherein XeF_2 gas is mixed with an inert carrier gas prior to its introduction into the etch chamber.

3. A method as claimed in Claim 1 or Claim 2 wherein the XeF_2 source continues to subliminate going outward flow from the reservoir.

4. A method as claimed in any one of Claims 1 to 3 including recharging the reservoir between etches.

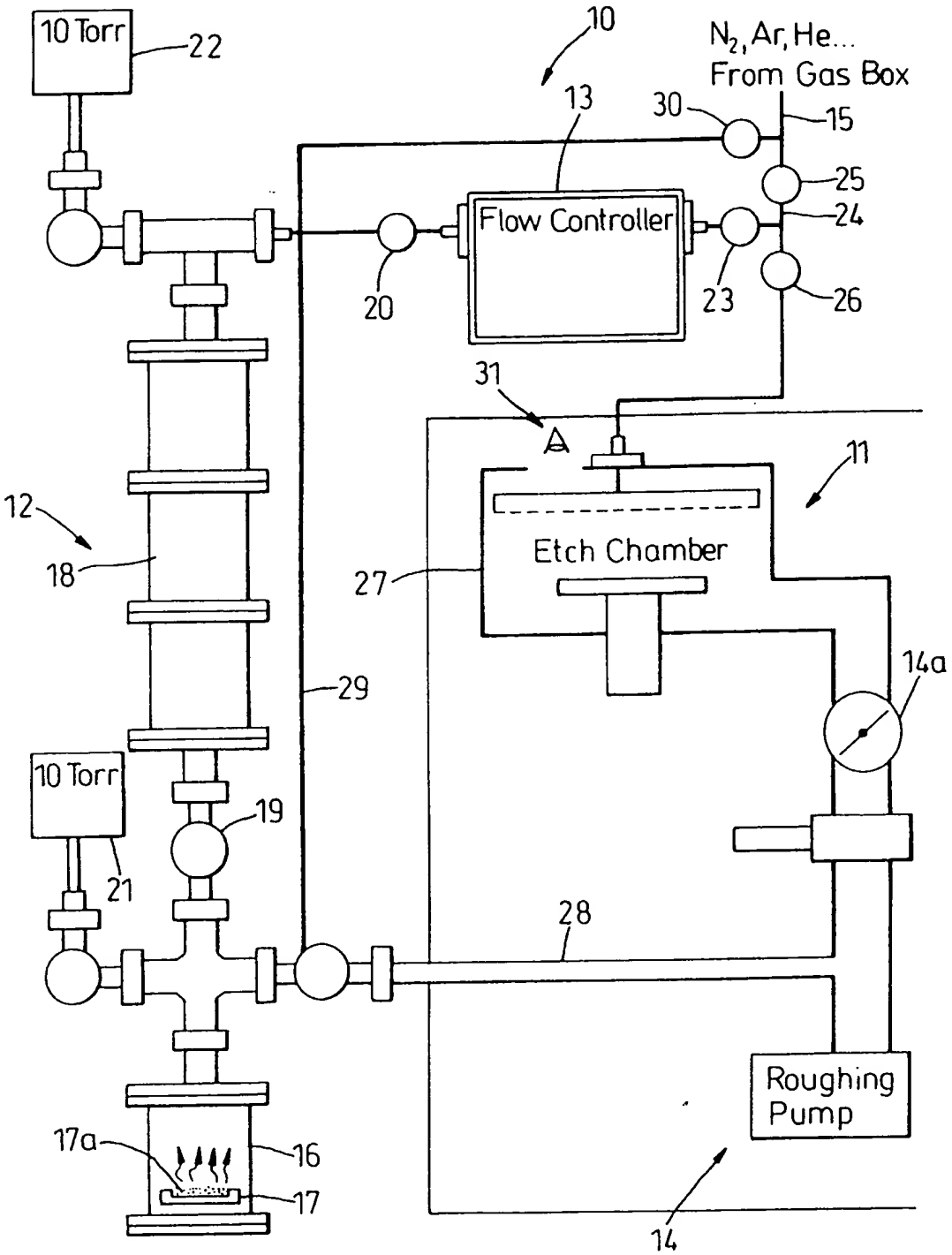
5. A method as claimed in any one of the preceding Claims wherein the flow rate is controlled on a pressure basis.

6. Apparatus for etching a workpiece comprising an etch chamber, a XeF_2 source, a reservoir, valve means for connecting the source to the reservoir to allow sublimination of the source into XeF_2 gas, a flow control of the feeding of the etch chamber and valve means or connecting the reservoir to the flow controller.

7. Apparatus as claimed in Claim 6 further including pressure control means for maintaining the reservoir at approximately sublimination pressure of XeF_2, when there is no outward flow from the reservoir.

8. Apparatus as claimed in Claim 6 or Claim 7 further comprising means for mixing the XeF_2 gas with an inert carrier gas prior to its introduction into the process.

9. Apparatus as claimed in any one Claim 6 to 8 when the flow controller is a pressure based flow controller.


10 Torr
22
10
N_2, Ar, He...
From Gas Box
13
30
15
25
24
Flow Controller
20
23
26
31
A
11
12
18
Etch Chamber
27
14a
29
10 Torr
19
21
28
Roughing
Pump
17a
16
17
14